Commuter Rail Safety in the Presence of Freight Rail

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ABSTRACT:

Commuter rail transit (CRT) lines were ranked according the relative intensity of freight rail traffic sharing the same route. The safety of CRT systems are examined within the context of the 2008 Union Pacific collision involving the Los Angeles Metrolink train. Patron fatalities from collisions are not predictable based on the level of freight intensity on a route. They are much more dependent upon many other things such as falls at the station or other mishaps. More fatalities happen from trespassing and at crossings, rather than through collisions, but Positive Train Control (PTC) will likely improve patron and employee safety by preventing collisions. PTC will result in lower fatalities, but many other causes of fatality must also be addressed.

INTRODUCTION:

On September 12, 2008, a Union Pacific train and a Metrolink Commuter Rail Transit (CRT) train collided, which resulted in the deaths of 25 and injuries to more than 135 Metrolink passengers. This accident "occurred on a horseshoe-shaped section track in Chatsworth, California at the west end of the San Fernando Valley, near a 500-foot-long tunnel underneath Stoney Point Park. There is a siding at one end of the tunnel where one train can wait for another to pass." (*1*) Neither freight nor commuter train yielded which resulted in head-on collision.

Investigators believe there are two possible scenarios for this mishap. Some believe that the cause was negligence on the part of the train engineer. He was believed to have been text messaging while operating the vehicle and failed to stop at a red signal. (*2*) Another possibility being checked by the National Transportation Safety Board (NTSB) was that there was a signal malfunction.

The Rail Safety Improvement Act of 2008 was in response to specific rail accidents and is an effort to prevent any reoccurrences. The Act requires that Positive Train Control (PTC) be implemented by 2012. This detects and shuts down trains heading towards each other. (*3*)

Previously, there were no statistics available about the relative freight rail traffic on commuter rail lines. A question arose about whether some CRT systems were free of freight traffic and therefore possibly safer.

Development of Commuter Rail Transit

The history of commuter rail transit (CRT) dates back to the early 1800's. Then, commuters were not transported on high-speed technologically advanced machines. They were slowly pulled by man or horse power on a railway designed to keep its travelers on course. It wasn't until the 1830s when agencies such as South Carolina Canal and Rail Road Company and the Baltimore and Ohio Railroad began to use steam locomotives and become common passenger carriers respectively. Rail transit proved its worth during the American Civil War as a means of transporting goods and soldiers where needed, and may have ultimately contributed to the Union victory. (*4*)

After the Trans-Continental Railroad was finished in 1869, rail quickly became a popular and scenic way to travel from state to state. (*4*) Along with this came the introduction of "interurban" rail which developed a large network by 1910. Interurban rail was a precursor to light-rail since it used lighter gauge rails. It served as one of the early predecessors of commuter rail transit since it provided local transportation within a city or region. They were not as successful as some imagined they would be, and

> "Many did not survive the 1920s following the country's growing adoption of the automobile and added to this was the onset of the Great Depression. The Great Depression finally drove most interurban systems into bankruptcy in the 1930s."(*5*)

Many abandoned lines were either converted to freight lines or overtaken by other transit agencies.

In 1971, the National Railroad Passenger Corporation, better known as Amtrak, began operating service in hope of satisfying interstate demands of rail travel. This was the government's attempt to make rail travel one of the most popular modes of travel again since the Great Depression. (*6*) This proved a difficult task with the increasing popularity of air travel. These routes were largely on existing track that was owned by freight companies, or purchased from them directly or through bankruptcy.

Currently, with rising fuel prices and increasing roadway congestion, a need has arisen for more "intercity" rail. Travel by rail could be enhanced from city to suburb or city to city. In some corridors, this could be through enhanced Amtrak service. Funding for intercity rail is promised through the stimulus plans. (*7*)

As intercity rail is developed, planners need to know whether operating on track shared with high freight traffic will present a safety concern. It would be helpful to know if this sharing would slow down the CRT vehicles. The planners should also be aware of additional safety concerns.

State of Commuter Rail

The list of CRT systems was found from the 2006 Federal Transit Administration National Transit Database (NTD). (*8*) See Table 1 for the list of all systems reporting to the NTD in 2006. Refer back to this table throughout the paper whenever abbreviations are found for transit systems.

A system in Nashville TN, the Music Star East Corridor (MSC) Commuter Rail system opened in 2006. However, since it is a new system, data on safety was not available. Likewise, little data is available for new systems in Salt Lake City, UT and Albuquerque, NM.

TABLE 1 Commuter Rail Lines in 2006

Transit Agency	Urbanized Area (Primary City)	Passenger Miles (thousands)
MTA Long Island Rail Road (MTA LIRR)	New York, NY	2,207,016
New Jersey Transit Corporation (NJ TRANSIT)	New York, NY	2,128,606
Metro-North Commuter Railroad Company (MTA-MNCR)	New York, NY	1,784,760
Northeast Illinois Regional Commuter Railroad Corporation (Metra)	Chicago, IL	1,636,188
Massachusetts Bay Transportation Authority (MBTA)	Boston, MA	749,518
Southeastern Pennsylvania Transportation Authority (SEPTA)	Philadelphia, PA	490,512
Southern California Regional Rail Authority (Metrolink)	Los Angeles, LA	400,170
Peninsula Corridor Joint Powers Board (PCJPB)	San Francisco, CA	234,947
Maryland Transit Administration (MTA)	Baltimore, MD	221,361
Northern Indiana Commuter Transportation District (NICTD)	Chicago, IL	118,250
Virginia Railway Express (VRE)	Washington, DC	112,205
South Florida Regional Transportation Authority (TRI-Rail)	Miami, FL	84,727
North County Transit District (NCTD)	San Diego, CA	42,970
Central Puget Sound Regional Transit Authority (ST)	Seattle, WA	41,509
Altamont Commuter Express (ACE)	San Jose / Stockton, CA	30,172
Pennsylvania Department of Transportation (PENNDOT)	Harrisburg, PA	17,677
Dallas Area Rapid Transit (DART)	Dallas, TX	16,912
Northern New England Passenger Rail Authority (NNEPRA)	Boston, MA / Portland, ME	16,352
Fort Worth Transportation Authority (The T)	Fort Worth, TX	16,111
Connecticut Department of Transportation (CDOT)	Hartford, CT	8,955
Alaska Railroad Corporation (ARRC)	Anchorage, AK	2,278

A few of these rail systems fit the 2006 NTD definition of a CRT system, but the authors might not have included them in as CRT otherwise. Among them is the Alaska Railroad Corporation (ARRC). A ride on the ARRC from Fairbanks to Anchorage takes about eight hours. The ridership is mostly tourists, not commuters.

The Northern New England Passenger Rail Authority (NNERPA) system serves Portland ME to Boston MA on a rural route of about 100 miles. This appears to be more of an intercity line.

No system maps or web pages could be found for the Harrisburg PA system. Only a few Amtrak stations to Philadelphia could be confirmed.

The transit agencies for Dallas and Fort Worth are independently listed as hosting CRT systems. However, the only CRT system that could be found was a line running between them, the Trinity (the T). The NTD data for the two agencies might reflect this as a shared route. If true, this complicates analysis data for the Trinity system, by requiring that the safety and passenger mile data be combined for the two agencies.

Every system has unique characteristics that might influence safety. One thing interesting about the Northern Indiana line is that it goes down the middle of the street in Michigan City, IN. It is not in a median but in the pavement. At the 11th Avenue station the train stops in the middle of the road, then patron walk in front of traffic to board the train. A 2012 deadline has been set for moving the track out of the street. (*9*) This leads to a question of whether the CRT trains follow traffic laws like trolleys do when in the road.

FREIGHT INTENSITY

Each rail agency's route map was found by visiting the agency's official website. The routes were compared to the Federal Railway Administration's GIS Web Application. (*10*) The application allows users to identify the owners, track right holders, freight density code, and etc. The freight density codes are show in Table 2. The density code data is labeled as from 2005.

Table 2 FRA Freight Density Codes (*10*)

Density Code	Million Gross Metric Tons
0	<0.1, or unknown
1	0.1 – 4.9
2	5.0 – 9.9
3	10.0 – 19.9
4	20.0 – 39.9
5	40.0 – 59.9
6	60.0 – 99.9
7	100.0 and above

This data was used to rate the relative congestion that commuter rail systems would experience due to freight rail. However, the density code or tonnage of freight are not perfect measures of freight congestion. For example, a unit coal train and a mixed freight train would likely cause the same congestion for commuter rail, but the coal train would have a much higher tonnage.

Comments were generated about the freight visible on each system through looking at aerial maps. Google Earth and the actual route was located and distinctively labeled with the "path" tool within the program. Then each station could be located using the "place mark" tool. Next, evidence of freight was looked for to see whether or not these commuter lines share rail with freight trains. Indicators of freight were freight cars or trains, spurs leading to industrial areas, and freight yards.

Several other processes were considered as to how to rate CRT systems based on relative freight intensity. The ideal indicator of freight intensity would be the hours that freight trains are on a line or freight cars are being shunted up spurs. One possibility was the US Department of Transportation, Surface Transportation Board's Carload Waybill Sample. However, this data is protected because it contains confidential revenue information.

The ideal data would be train dispatching sheets for freight companies for during the hours of operation of the transit system. Contacting every railway operating in the right-of-way was considered, but if only one railway declined to provide the information, the results of this work would be incomplete.

It was noted from the aerial images that every CRT system had freight traffic, but not every line. For example, the last 75 miles of the Montauk route on the Long Island Railroad does not have any evidence of freight traffic. Even systems that don't share track rights with freight carriers had track maintenance equipment and the cars holding ballast would look like other freight cars. Even though those cars are not from an outside agency, they could present some of the same issues of inference between passenger and non-passenger functions.

Some systems have only one line. Even those routes have segments with more evidence of freight and segments with less. All systems with multiple lines have lines with less intensity than the worst case scenario.

Table 3 lists the most intensive and least intensive line for each system. The table is ranked by the average intensity for the system.

Considering the multiple methods that could have been used in order to rank the intensity of freight systems, the ranking in Table 3 should not be considered the exact and only answer. However, other ranking methods would have produced a similar result.

Right-of-Way

Today, over 90 percent of commuter rail trips are on lines that are publicly owned. (*11*) The FRA's GIS application was also used to find the ownership. (*10*) However, there was one error found in the ownership of the lines that the SFRTA uses. This might be due to the age of the data on the FRA's GIS site. For example, the GIS does not have the most recent density codes.

Table 4 shows the relationship between right-of-way ownership and intensity. Table 5 explains the abbreviations, although for many freight and public systems the abbreviations functions as the full corporate name. Notice that with one exception the top half freight intensive systems have freight company ownership of the right-of-way, or mixed between the freight company and public ownership. The bottom half all have public ownership. Also, looking line by line at mixed ownership systems, the more freight intensive lines were the ones that were owned by the private railways. The lines with little freight were largely publically owned.

To the authors, this is a significant trend. In order to accommodate very high freight intensity, it is necessary to leave more control in the hands of the freight companies. The trend in ownership confirms the characterization of Freight intensity, and it demonstrates that higher freight intensity may require freight railway ownership of the right-of-way.

TABLE 3 Freight Intensity Ranking

Agency	Worst Case Scenario		Best Case Scenario		Average
	FRA Density Code	Comment	FRA Density Code	Comment	FRA Density Code
CPSRTA (Seattle, WA)	6	The south route to Tacoma has several freight yards including some with 12 tracks.	5	The north route to Everett serves a few port facilities.	5.5
MTA-MARC (Baltimore, MD)	5-6	The 300 from Washington DC to W. Virginia has a 14 track freight yard.	1	The Mid-Atlantic line provides trackage rights to CSXT.	3.8
VRE (Washington, DC)	5	The South route to Fredericksburg has visible freight traffic, but only minor freight spurs.	2	The West route towards Manassas has an 8-track freight yard.	3.5
SCRRA (Los Angeles, CA)	7	Heavy BNSF traffic on the Inland Empire Line	0-6	Little freight traffic once the Orange County / San Diego Line gets out of Los Angeles.	3
SFRTA (Miami, FL)	3	The line at the Miami station bypasses a 22-track freight yard.	3	Has only one line. The northern end has a freight spur about every 5 miles.	3
ACE (Stockton, CA)	3	Has a freight yard with about 45 tracks.	2	Only minor spurs on south end.	2.8
NIRCRC (Chicago, IL)	6-7	Several large freight yards including a 70-track Union Pacific sorting yard.	0	The New Lenox Line doesn't have any evidence of freight.	2.7
PCJPB (San Francisco, CA)	2	Has a freight yard with 8 tracks.	1	Has only one line. The majority of the line has sparse freight spurs.	1.5
SEPTA (Philadelphia, PA)	4	The Trenton line has a 14-track freight yard.	0	Several routes such as Landsdale-Doylestown have sparse minor freight spurs then dead end after the last station.	0.5
MBTA (Boston, MA)	2-4	The Worchester line has an 17-track freight yard	0	The Rockport line has no freight over its last	0.4

		and attached active freight terminal.		15 miles.	
MTA-MNCR (New York, NY)	1	The Southern Tier line has sporadic spurs. The Hudson line has a freight yard of 18 tracks.	0	The Harlem line has no freight traffic and dead ends after the last station.	0.3
NNERPA (Portland, ME)	0	It is the main line to Maine and has a freight yard with about 50 tracks.	0	Has only one line. Has sparse spurs on the middle rural 80 miles between Boston and Portland.	0
NJ Transit (Hoboken, NJ)	0	The NEC line to Trenton has a freight yard with 25 tracks.	0	The Atlantic City line appears free of freight.	0
NCTD (San Diego, CA)	0	Goes through a freight yard with 13 tracks.	0	Has only one line. Although on the mainline to San Diego, the northern extent has sparse freight spurs.	0
DART & FWTA (Dallas & Fort Worth TX)	0	Goes through a freight yard with 13 tracks.	0	Has only one line. At the Fort Worth end, the line bypasses a freight yard.	0
ARRC (Anchorage, AK)	0	The only line to Anchorage. Has an 11-track freight yard.	0	Has only one line. The northern 180 miles is sparsely inhabited.	0
NICTD (Gary, IN)	0	Sides with heavy industry near Chicago such as a car manufacturer with a five track loading facility.	0	Has only one line. The Eastern end has freight spurs only every 8 miles.	0
LIRR (Long Island, NY)	0	Sparse evidence of freight traffic. No freight yards on the route. Freight spurs are about one per four miles.	0	The last 75 miles of the Montauk route have no evidence of freight traffic.	0
CDOT (Hartford , CT)	0	Only about 4 freight spurs in the entire systems.	0	The New Canaan line dead ends after the last station and has no freight spurs on its unique section of track.	0

TABLE 4 Owned Right-Of-Way

Agency Ranked by Freight Intensity	Right-Of-Way Ownership (*10, 11*)
CPSRTA (Seattle, WA)	Freight rail owns track, FRA shows BNSF, and UP
MTA-MARC (Baltimore, MD)	Mixed Ownership, FRA shows CSXT and AMTK
VRE (Washington, DC)	Freight rail owns track, FRA shows CSXT and NS
SCRRA (Los Angeles, CA)	Mixed Ownership, FRA shows SCRA, UP, LACM, BNSF
SFRTA (Miami, FL)	Publically owned by SFRTA, but FRA still shows CSXT
ACE (Stockton, CA)	Freight rail owns track, FRA shows UP
NIRCRC (Chicago, IL)	Mixed Ownership, FRA shows UP, CPRS, MTRA, CN, BNSF, IAIS, NS
PCJPB (San Francisco, CA)	Mixed Ownership, FRA shows PJPB and UP
SEPTA (Philadelphia, PA)	Largely Publicly owned, FRA shows SEPA, CSXT and AMTK
MBTA (Boston, MA)	Mixed Ownership, FRA shows mostly MBTA but also some CSXT, BCLR and ST
MTA-MNCR (New York, NY)	Publicly owned, FRA shows MNCW
NNERPA (Portland, ME)	Freight rail owns track, FRA shows ST
NJ Transit (Hoboken, NJ)	Publicly owned, FRA shows NJT
NCTD (San Diego, CA)	Publicly owned, FRA shows SCRA
DART & FWTA (Dallas & Fort Worth TX)	Publicly owned, FRA shows DART
ARRC (Anchorage, AK)	Publicly owned, FRA shows ARR
NICTD (Gary, IN)	Publically owned by NICTD, but FRA shows CSS
LIRR (Long Island, NY)	Publicly owned, FRA shows LI
CDOT (Hartford , CT)	Publicly owned, FRA shows MNCW

Table 5 Railway Abbreviations

Abbreviation	Unabbreviated
UP	Union Pacific
BNSF	Burlington Northern-Santa Fe
CSXT	Chessie System Transportation
NS	Norfolk Southern
AMTK/Amtrak	National Railroad Passenger Corporation
LACM	Los Angeles County Metropolitan Transit Authority
CPRS	Canadian Pacific Railway
CN	Canadian National
BCLR	Balcony Colony Railroad
ST	Springfield Terminal (Private, Freight Carrier)
CSS	(Private, Freight Carrier)
IAIS	Iowa Interstate Railroad (Private, Freight Carrier)

Influence of Freight on CRT Speed

Obviously, when a CRT train needs to wait behind a freight train, it causes delay. Table 6 shows freight intensity matched with the average operating speed that was calculated as revenue miles divided by revenue hours.

Table 6 shows that there is no trend in CRT speed related to freight intensity. A plot of intensity versus speed could be made. However, it would not show a trend of higher speeds in lower freight systems. It is more likely that freight is delayed in presence of commuter rail since commuter rail often has priority over freight.

The correlation between the speed and freight intensity is insignificant (6%). There is great variability in speeds between CRT systems. The fastest and the slowest systems both have a zero FRA Density Code. Other things are a better predictor of speed. Waiting for a freight train obviously influences the speed, but the lack of significance of this largely because freight and CRT managers dispatch trains in such a way as to minimize delay. (*11*)

Other factors have greater impact on operating speed. For example, in Figure 1 the operating speed is plotted versus the frequency of stations. It is see that there is a strong relationship between the two.

The correlation coefficient is 0.53, which means that 53% or a majority of the determinant of a system's speed is how many stations it has. When trains stop at stations, it influences their average speed.

There are other reasons for variability in speed. For example, until 2007 the South Florida system serving Miami had to stop whenever the drawbridge over the New River was up.

There is a potential for quite a bit of variability of speed within a system, or even on segments of a line. The San Bernardino line in Los Angeles goes down dedicated track in a freeway median and comes into an area that is an industrial center that has several freight spurs.

A Federal Railroad Administration (FRA) study looked at the causes of Amtrak delays. (12) It found that the biggest problems were the host railroad's dispatching practices, speed restrictions due to track, insufficient capacity, and external factors. Since Amtrak stations are much further apart than in commuter rail lines, the number of stations has less of an influence on speed than for CRT systems.

Note that the Alaska Railroad was removed from the stations versus speed plots. The trains on that route are possibly more controlled by geographic limits on track geometry, and a desire for a scenic pace.

SAFETY

In its infancy stage, railroad proved relatively reliable and safe as a mode of transportation because it was more resilient to weather conditions. River transport failed during extreme weather conditions while railroads remained in operation rain or shine. Because rail transportation proved to be effectiveness, continuous improvements were sought to make the system safer for patrons, employees, and the public.

TABLE 6 Average Speed

Agency Ranked by Freight Intensity	Average operating speed 2002-2006 (mph)
CPSRTA (Seattle, WA)	38.1
MTA-MARC (Baltimore, MD)	39.1
VRE (Washington, DC)	33.4
SCRRA (Los Angeles, CA)	40.5
SFRTA (Miami, FL)	36.5
ACE (Stockton, CA)	38.1
NIRCRC (Chicago, IL)	30.1
PCJPB (San Francisco, CA)	31.1
SEPTA (Philadelphia, PA)	27.1
MBTA (Boston, MA)	31.9
MTA-MNCR (New York, NY)	35.1
NNERPA (Portland, ME)	46.3
NJ Transit (Hoboken, NJ)	30.3
NCTD (San Diego, CA)	42.2
DART & FWTA (Dallas & Fort Worth TX)	21.3
ARRC (Anchorage, AK)	19.3
NICTD (Gary, IN)	36.1
LIRR (Long Island, NY)	28.8
CDOT (Hartford , CT)	43.2

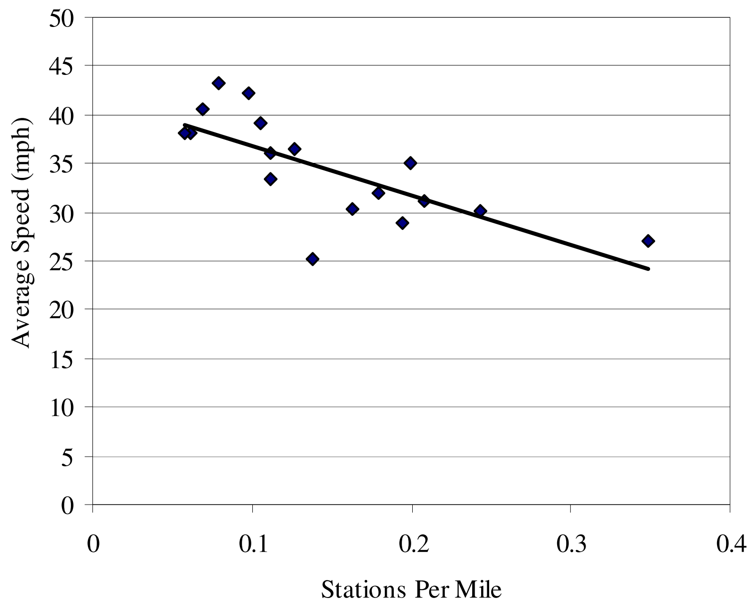

FIGURE 1 Average Speed Versus Stations Per Mile

Patron Safety

The 2008 accident in Los Angeles between the Union Pacific and the Metrolink was partially what spurred the authors to do this research. However, this accident needs to be put into perspective with respect to other accidents.

This was accident "the deadliest since Sept. 22, 1993, when the Sunset Limited, an Amtrak train, plunged off a trestle into a bayou near Mobile, Ala., moments after the trestle was damaged by a towboat; 47 people were killed." (*13*)

One of the biggest commuter rail accidents was on the Long Island Railroad on November 22, 1950 where 78 people died. The accident was between two commuter trains. The front train was stopped at the Kew Gardens station. The engine was having trouble with locked brakes. At the time, the end of a stopped train was to be marked by the conductor who was to wave his lantern. As the engine revved to try to unfreeze the brakes, the conductor thought the train was leaving so he extinguished his lantern and boarded the train. Sometime later a second commuter train approached in the dark and collided with the first train. There was also probably confusion about a Go Slow signal that lead to the accident. In the aftermath, Automatic Speed Control was installed on the tracks. (*14*) In this instance freight traffic played no role in the accident. Although unfortunate, this accident led to enhanced safety procedures.

Accident statistics were reported in the Commuter Rail Safety Study (CRSS) in 2006 for the four and a half year time period previous. (*15*) This report didn't have accident rates for the Portland or South Florida systems. The Alaska Railroad was thrown out from the analysis below because according to the reference, its accidents were dramatically higher than all of the other systems.

Accidents per 1 million passenger miles and one thousand revenue miles are shown in Table 7. No trend is seen between freight intensity and accidents. Several correlations were attempted between freight intensity and accidents. For example, total accidents, derailments, non-derailments were all proposed as related to freight intensity. However, none of these produced a relationship with any significance to the correlation. In fact, the most significant correlation (11%) showed a slight decrease in accidents per 1 million passenger miles for CRT systems with higher freight. Although the correlation is insignificant, it brings up interesting issues of whether a CRT system can be safer because it is around freight traffic.

TABLE 7 Accidents

Agency Ranked by Freight Intensity	Accidents per 1 million passenger miles	Accidents per 1000 Revenue CRT miles
CPSRTA (Seattle, WA)	0.21	0.0123
MTA-MARC (Baltimore, MD)	0.29	0.0119
VRE (Washington, DC)	0.34	0.0211
SCRRA (Los Angeles, CA)	0.32	0.0091
SFRTA (Miami, FL)	NA	NA
ACE (Stockton, CA)	0.22	0.0078
NIRCRC (Chicago, IL)	0.07	0.0053
PCJPB (San Francisco, CA)	0.16	0.0083
SEPTA (Philadelphia, PA)	0.46	0.0172
MBTA (Boston, MA)	0.03	0.0018
MTA-MNCR (New York, NY)	0.70	0.0430
NNERPA (Portland, ME)	NA	NA
NJ Transit (Hoboken, NJ)	0.51	0.0249
NCTD (San Diego, CA)	0.67	0.0236
DART & FWTA (Dallas & Fort Worth TX)	0.24	0.0084
ARRC (Anchorage, AK)	7.89	NA
NICTD (Gary, IN)	0.12	0.0042
LIRR (Long Island, NY)	0.18	0.0131
CDOT (Hartford , CT)	0.84	0.0104

This shows that being in a freight intensive area does not cause significantly more accidents. Except for derailments which are not caused by collisions, a large number of the accidents are from activities such as raking that happen in the CRT yards.

Freight collisions with CRT vehicles are not very common. However, when they do happen, they tend to be very newsworthy because of the fatalities. Therefore, looking at the causes of patron fatalities should show the prevalence of freight collisions.

According to the CRSS, over the four and a half years before the report in 2006, there were only 20 fatalities of passengers while on the trains. (*15*) That is 4.4 patron deaths per year. Twelve patron fatalities were as a result of derailment. Only a couple fatalities are related to collisions between CRT and freight or other CRT.

Positive train control will save lives by preventing accidents of CRT with CRT vehicles or freight. However, there is likely as many people who die of natural causes as in collisions. Other safety procedures might do much more to reduce total fatality rates. For example, a transit agency might find that putting defibrillators on trains and in stations and training employees in CPR could do more for patron safety than PTC. Future work could consider the cost to benefits of doing this.

There are other safety procedures that can improve safety at stations or while boarding the CRT vehicles. For example, for many years the Long Island Railroad had a problem with patrons falling into the gaps between the platform and the vehicle. (*16*) Up to 80 patrons a year fell into the gap, some of whom died. Gap covers have reduced the falls.

Trespasser Safety

The CRSS reports that there were 509 trespasser deaths over a ten year period which was 51 per year. (*15*) This exceeds patron deaths by a factor of 11. If a transit agency wanted to do the most to improve public safety, reducing trespasser deaths would have the most impact proportionately.

In a study about trespasser deaths on rail systems in North Carolina, it was found "One hundred twenty-eight persons ranging in age from 7 to 84 years who were killed in 125 separate incidents." Through various research methods it was concluded that "Of 224 railroad-related deaths during the study period, 128 cases (57%) involved trespassers. Trespasser fatalities typically involved unmarried male pedestrians 20 to 49 years of age with less than a high school education. Eighty-two percent of incidents occurred in the trespassers' county of residence, indicating that few deaths involved transients. Fatalities among railroad trespassers exhibited both geographic and temporal clustering. Seventy-eight percent of trespassers were killed while intoxicated (median alcohol level, 56 mmol/L [260 mg/dL])." (*17*) The study author suggested that education on alcohol abuse and avoiding the dangers of trespassing would be most effective at reducing this.

Since very low cost cameras are now available, more options exist for trespasser safety. An automated camera security system could notify security personnel when trespassers are on rail right-of-way. (*18*)

Highway At-Grade Crossing Safety

The CRSS reports that there were 109 deaths at crossings of rail and highways over a ten-year period which was 11 per year. This also exceeds the patron deaths. This does not represent the total crossing deaths on CRT routes because freight trains also may have caused other deaths at the same crossings.

"The nation saw 2,466 train/vehicle crashes resulting in 309 fatalities and 874 injuries from January to November 2007." (*19*) Although CRT traffic is low relative to freight traffic nationwide, CRT and Amtrak vehicles often travel faster than freight trains. Therefore, crossing safety may be a bigger issue for CRT trains than freight.

Operation Lifesaver is a public education program to keep drivers from going around crossing gates. Also barricades can be used to provide a physical obstruction to getting around the gate. However, so that emergency vehicles can get around the gates the barricades should be flexible. (*19*)

Another possibility is enforcing crossing traffic laws through the threat of automatic traffic tickets. Several cities have been using cameras to enforce traffic signals by automatically sending tickets to drivers who disobey red lights. (*20*) This technology could be used for railroad crossings.

Employee Safety

Early in rail history there were no laws regulating labor, therefore their casualty numbers increased steadily as the industry expanded. The "Robber Barons" (or often called captains of industry) of the industrial era showed very little concern for their workers and the compensation they were paid for strenuous work. They called Robber Barons because they were "businessmen and bankers who dominated their respective industries and amassed huge personal fortunes, typically as a direct result of pursuing various anti-competitive or unfair business practices."(*21*) They were only concerned with increasing capital and thought of their workers to be rather disposable. This was unsettling to many workers and their families and resulted in the formation of labor unions.

Boycotts and strikes were orchestrated by these workers to finally obtain the rights and protection due to them. The Pullman Strike of 1894 was a turning point in the lives of many laborers. Employees of the Pullman Palace Car Company felt they were over-worked and underpaid and appealed to the American Railway Union to negotiate a pay increase on their behalf. The company failed to comply and workers walked off of the assembly lines in protest. The Pullman company finally gave in to its workers' demands but not because it cared about them. They were steadily losing money due to the stalemate and felt something had to be done to resume cash flow. This ultimately led to the legislation of the Adamson Act of 1916, Transportation Act of 1920, and the Railway Labor Act of 1926. (*22*)

The Adamson Act of 1916 "… provided workers with an eight hour [work] day, at the same daily wage they had received previously for a ten hour day, and required time and a half for overtime."(i) The Transportation Act of 1920 resulted in the creation of the Railroad Labor Board who had "…the power to issue non-binding proposals for the resolution of labor disputes…" (*22*) The Railway Labor Act of 1926 "… governs labor relations in the railway and airline industries. [It] seeks to substitute bargaining, arbitration and mediation for strikes as a means of resolving labor disputes." (*22*)

Though casualty numbers have steadily decreased in the last century, there is still room for improvement.

The CRSS looked at employee injury. "In looking at the injuries reported during the 79-month study period, it is clear that the employee and contractor injuries account for the majority (66 percent)… it is interesting to note that human factors issues are responsible for more than half of the injuries to employees/contractors, passengers, and non-trespassers on railroad property. This appears to be an area which may benefit from additional analysis and research. Environmental conditions, mainly poor weather, are responsible for 13 percent of employee injuries, 11 percent of passenger injuries, and 24 percent of injuries to non-trespassers on railroad property. Equipment failures are responsible, across the boards for approximately 10 percent of injuries to employees/contractors, passengers and non-trespassers on railroad property. Finally, failure to follow operating procedures is accountable for more than 10 percent of employee injuries and approximately one percent of injuries to passengers and non-trespassers on railroad property." (*15*)

The majority of these injuries do not appear to be related to possible interference with freight trains. Since employee fatalities are relatively low, comparing them to the freight index on CRT systems would not produce statistically reliable results.

Recent steps have to further improve safety such as in the Rail Safety Improvement Act (RSIA) of 2008 requires the use of Positive Train Control technology across US rail systems. (*3*) This will obviously improve employee safety as well as for patrons.

Also, organizations such as the Switching Operations Fatalities Analysis (SOFA) group "with representatives from the Federal Railroad Administration (FRA), labor and management, was formed at the request of the FRA to review recent employee fatalities and to develop recommendations for reducing fatalities in switching operations" (*23*).

CONCLUSIONS

The intensity of freight rail on commuter rail routes was found through aerial maps. Evidence showed a wide range of freight activity from system to system and even within the systems. CRT agencies were ranked according to intensity of freight as determined by the largest freight yard on their system.

Freight companies had outright or mixed ownership of the right-of-way in the CRT systems with the highest freight intensity. The may have needed this in order to efficiently conduct business.

Freight intensity on commuter rail systems did not have a statistically significant influence on the average speed of a CRT vehicle. However, freight does cause random delays. Coordination with freight companies may have alleviated these delays to the point that they became statistically insignificant.

Spacing of stations was the most significant determinant of CRT vehicle average speed. New systems planned for intercity service will likely have fewer stations than CRT transit therefore they will have higher average speeds.

Having intense freight traffic on commuter rail routes did not cause statistically significant higher accidents or fatalities. Positive Train Control will save lives when implemented, but it will not have a dramatic effect on the total fatality rate of employees or patrons.

Patron safety may be more influenced through other things such as placing defibrillators on trains and in stations. Employee safety is mostly a function of human factors, so safety awareness programs used in other industries could have an impact. Trespasser safety might be positively influenced by use of modern image recognition cameras. Safety at crossings might also be improved through use of cameras to give automatic traffic violation tickets.

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